

AXIAL-FLOW OUTBOARD
JET PROPULSION UNIT

FIELD OF THE INVENTION

This invention generally relates to water jet propulsion systems for propelling boats or other watercraft. In particular, the invention relates to outboard water jet propulsion units comprising an engine and a ducted impeller driven by the engine.

BACKGROUND OF THE INVENTION

Jet-powered boats can be categorized in part in accordance with the types of propulsion systems used. The powerhead can be mounted either inside the hull or outside the hull. In the latter case, the powerhead is mounted on the transom portion of the boat hull and is detachable. Another type of system, called a stern drive system, and sometimes referred to an inboard-outboard system, utilizes a powerhead mounted inside the hull of the boat with a portion of the drive unit extending through the transom. These systems create thrust through rotation of a ducted impeller, which draws water from ahead and impels the water rearward to propel the boat forward.

To facilitate use of water jet-propelled boats in shallow water, it is known to mount the ducted an impeller at an elevation such that the propulsion unit does not project below the bottom of the boat hull. This can be accomplished, for example, by installing a duct in the stern of the boat, the duct being arranged to connect one or more inlet holes formed in the bottom of the hull with an outlet hole formed in the transom. The water jet is then installed outside the hull in a position such that the water jet inlet is in fluid communication with the duct outlet at the transom. Alternatively, a water tunnel is formed in the bottom of the hull which is open at the

bottom and at the transom. A water jet propulsion unit is then mounted to the transom by means of a mounting adapter, the inlet of the propulsion unit being in fluid communication with the water tunnel via the adapter.

5 The use of outboard water jet propulsion units is not new to the marine industry. However, the majority of these applications utilize a centrifugal pump, which allows the propulsion unit to be designed so that it does not extend below the hull bottom. An axial-flow pump is
10 disclosed in U.S. Patent No. 3,842,787. However, the inlet duct of that system extends below the hull bottom.

 There is a need for an axial-flow outboard water jet propulsion unit which does not extend below the hull bottom.

15 As used herein, the term "axial-flow pump" means a ducted impeller in which the water is impelled in a direction generally parallel to the axis of impeller rotation. This is in contrast to a centrifugal pump, in which water is impelled radially outward in directions
20 perpendicular to the axis of impeller rotation.

SUMMARY OF THE INVENTION

 The present invention is directed to an outboard water jet propulsion unit comprising an axial-flow pump. Preferably the water jet propulsion unit is designed so that it does not extend below the bottom of the boat
25 hull, but rather is disposed directly behind the hull transom. This is achieved by arranging the impeller shaft generally perpendicular to a generally vertical drive shaft, and by installing the impeller in a flow-through duct which, although placed directly behind the transom,
30 has an inlet for taking in water located directly below the impeller shaft. In the preferred embodiment of the invention, the duct does not extend to a depth lower than the lowest point of the hull bottom. The impeller shaft

penetrates the duct wall, while the impeller itself is rotatable inside the duct. The impeller impels water rearward toward a convergent exit nozzle of the duct, sucking in water through the duct intake. The aft opening of the exit nozzle forms the duct discharge outlet.

In accordance with the preferred embodiment of the invention, the propulsion unit comprises: an engine support housing; an engine supported by the engine support housing; a drive shaft having one end coupled to the engine; an inlet housing attached to and located beneath the engine support housing; and an outlet housing attached to the rear of the inlet housing. The inlet housing comprises a flow-through passage having an inlet and an outlet. The outlet housing comprises a flow-through passage in fluid communication with the inlet housing passage. Preferably, the outlet housing passages converges toward an outlet. The inlet and outlet housings form a duct. In addition, the propulsion unit may comprises: an impeller shaft which penetrates a wall of the inlet housing; an impeller mounted to the impeller shaft and rotatable within the inlet housing passage; bearings for rotatably supporting the shafts; and gears for converting rotation of the drive shaft into rotation of the impeller shaft. The impeller shaft is generally perpendicular to the drive shaft, and the inlet of the inlet housing lies underneath the impeller shaft.

In accordance with a further feature of the preferred embodiment, the engine support housing, the inlet housing and the outlet housing each comprise a respective exhaust gas passage. These exhaust gas passages are connected in series so that exhaust gas from the engine is discharged below the waterline.

In accordance with another feature of the preferred embodiment, the gears are housed in a gear housing which is integrally formed with the inlet housing.

In addition, a steering nozzle is pivotably mounted to the exit nozzle. The steering nozzle is pivotable about an axis which is generally perpendicular to the impeller shaft. Because the boat can be steered by turning the steering nozzle, the outboard water jet propulsion unit does not need to be pivotable about a vertical axis, thereby simplifying the mounting of the outboard propulsion unit to the boat hull.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a schematic showing an isometric view of an outboard water jet propulsion unit in accordance with the preferred embodiment of the invention.

FIG. 2 is a schematic showing an exploded view of a jet pump unit incorporated in the outboard water jet propulsion unit shown in FIG. 1.

FIG. 3 is a schematic showing an exploded view of the outboard water jet propulsion unit shown in FIG. 1, with the axial-flow jet pump unit assembled.

FIG. 4 is a schematic showing a partially sectioned view of the outboard water jet propulsion unit in accordance with the preferred embodiment of the invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

An outboard water jet propulsion unit 10, in accordance with the preferred embodiment of the invention, is shown in FIG. 1, mounted to a hull transom 12. As will be explained in more detail below with reference to exploded and sectional views of the system, the engine (not visible behind motor cover 14 in FIG. 1) is mounted on and supported by an exhaust housing 16, while the inlet/gear housing 18 is located below and supported by the exhaust housing 16. The exhaust housing comprises a pair of support arms 30, by means of which

the exhaust housing (and the entire unit) can be hung on the top edge of the hull transom 12. The water intake is located at the bottom of the inlet/gear housing 18 and is not visible in FIG. 1. An outlet housing 20 is attached to the rear face of the inlet housing. Preferably the outlet housing comprises a convergent exit nozzle for increasing the pressure of the water discharge.

23
22
21
20
19
18
17
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
-1
-2
-3
-4
-5
-6
-7
-8
-9
-10
-11
-12
-13
-14
-15
-16
-17
-18
-19
-20
-21
-22
-23
-24
-25
-26
-27
-28
-29
-30
-31
-32
-33
-34
-35
-36
-37
-38
-39
-40
-41
-42
-43
-44
-45
-46
-47
-48
-49
-50
-51
-52
-53
-54
-55
-56
-57
-58
-59
-60
-61
-62
-63
-64
-65
-66
-67
-68
-69
-70
-71
-72
-73
-74
-75
-76
-77
-78
-79
-80
-81
-82
-83
-84
-85
-86
-87
-88
-89
-90
-91
-92
-93
-94
-95
-96
-97
-98
-99
-100
-101
-102
-103
-104
-105
-106
-107
-108
-109
-110
-111
-112
-113
-114
-115
-116
-117
-118
-119
-120
-121
-122
-123
-124
-125
-126
-127
-128
-129
-130
-131
-132
-133
-134
-135
-136
-137
-138
-139
-140
-141
-142
-143
-144
-145
-146
-147
-148
-149
-150
-151
-152
-153
-154
-155
-156
-157
-158
-159
-160
-161
-162
-163
-164
-165
-166
-167
-168
-169
-170
-171
-172
-173
-174
-175
-176
-177
-178
-179
-180
-181
-182
-183
-184
-185
-186
-187
-188
-189
-190
-191
-192
-193
-194
-195
-196
-197
-198
-199
-200
-201
-202
-203
-204
-205
-206
-207
-208
-209
-210
-211
-212
-213
-214
-215
-216
-217
-218
-219
-220
-221
-222
-223
-224
-225
-226
-227
-228
-229
-230
-231
-232
-233
-234
-235
-236
-237
-238
-239
-240
-241
-242
-243
-244
-245
-246
-247
-248
-249
-250
-251
-252
-253
-254
-255
-256
-257
-258
-259
-260
-261
-262
-263
-264
-265
-266
-267
-268
-269
-270
-271
-272
-273
-274
-275
-276
-277
-278
-279
-280
-281
-282
-283
-284
-285
-286
-287
-288
-289
-290
-291
-292
-293
-294
-295
-296
-297
-298
-299
-300
-301
-302
-303
-304
-305
-306
-307
-308
-309
-310
-311
-312
-313
-314
-315
-316
-317
-318
-319
-320
-321
-322
-323
-324
-325
-326
-327
-328
-329
-330
-331
-332
-333
-334
-335
-336
-337
-338
-339
-340
-341
-342
-343
-344
-345
-346
-347
-348
-349
-350
-351
-352
-353
-354
-355
-356
-357
-358
-359
-360
-361
-362
-363
-364
-365
-366
-367
-368
-369
-370
-371
-372
-373
-374
-375
-376
-377
-378
-379
-380
-381
-382
-383
-384
-385
-386
-387
-388
-389
-390
-391
-392
-393
-394
-395
-396
-397
-398
-399
-400
-401
-402
-403
-404
-405
-406
-407
-408
-409
-410
-411
-412
-413
-414
-415
-416
-417
-418
-419
-420
-421
-422
-423
-424
-425
-426
-427
-428
-429
-430
-431
-432
-433
-434
-435
-436
-437
-438
-439
-440
-441
-442
-443
-444
-445
-446
-447
-448
-449
-450
-451
-452
-453
-454
-455
-456
-457
-458
-459
-460
-461
-462
-463
-464
-465
-466
-467
-468
-469
-470
-471
-472
-473
-474
-475
-476
-477
-478
-479
-480
-481
-482
-483
-484
-485
-486
-487
-488
-489
-490
-491
-492
-493
-494
-495
-496
-497
-498
-499
-500
-501
-502
-503
-504
-505
-506
-507
-508
-509
-510
-511
-512
-513
-514
-515
-516
-517
-518
-519
-520
-521
-522
-523
-524
-525
-526
-527
-528
-529
-530
-531
-532
-533
-534
-535
-536
-537
-538
-539
-540
-541
-542
-543
-544
-545
-546
-547
-548
-549
-550
-551
-552
-553
-554
-555
-556
-557
-558
-559
-560
-561
-562
-563
-564
-565
-566
-567
-568
-569
-570
-571
-572
-573
-574
-575
-576
-577
-578
-579
-580
-581
-582
-583
-584
-585
-586
-587
-588
-589
-590
-591
-592
-593
-594
-595
-596
-597
-598
-599
-600
-601
-602
-603
-604
-605
-606
-607
-608
-609
-610
-611
-612
-613
-614
-615
-616
-617
-618
-619
-620
-621
-622
-623
-624
-625
-626
-627
-628
-629
-630
-631
-632
-633
-634
-635
-636
-637
-638
-639
-640
-641
-642
-643
-644
-645
-646
-647
-648
-649
-650
-651
-652
-653
-654
-655
-656
-657
-658
-659
-660
-661
-662
-663
-664
-665
-666
-667
-668
-669
-670
-671
-672
-673
-674
-675
-676
-677
-678
-679
-680
-681
-682
-683
-684
-685
-686
-687
-688
-689
-690
-691
-692
-693
-694
-695
-696
-697
-698
-699
-700
-701
-702
-703
-704
-705
-706
-707
-708
-709
-710
-711
-712
-713
-714
-715
-716
-717
-718
-719
-720
-721
-722
-723
-724
-725
-726
-727
-728
-729
-730
-731
-732
-733
-734
-735
-736
-737
-738
-739
-740
-741
-742
-743
-744
-745
-746
-747
-748
-749
-750
-751
-752
-753
-754
-755
-756
-757
-758
-759
-760
-761
-762
-763
-764
-765
-766
-767
-768
-769
-770
-771
-772
-773
-774
-775
-776
-777
-778
-779
-780
-781
-782
-783
-784
-785
-786
-787
-788
-789
-790
-791
-792
-793
-794
-795
-796
-797
-798
-799
-800
-801
-802
-803
-804
-805
-806
-807
-808
-809
-810
-811
-812
-813
-814
-815
-816
-817
-818
-819
-820
-821
-822
-823
-824
-825
-826
-827
-828
-829
-830
-831
-832
-833
-834
-835
-836
-837
-838
-839
-840
-841
-842
-843
-844
-845
-846
-847
-848
-849
-850
-851
-852
-853
-854
-855
-856
-857
-858
-859
-860
-861
-862
-863
-864
-865
-866
-867
-868
-869
-870
-871
-872
-873
-874
-875
-876
-877
-878
-879
-880
-881
-882
-883
-884
-885
-886
-887
-888
-889
-890
-891
-892
-893
-894
-895
-896
-897
-898
-899
-900
-901
-902
-903
-904
-905
-906
-907
-908
-909
-910
-911
-912
-913
-914
-915
-916
-917
-918
-919
-920
-921
-922
-923
-924
-925
-926
-927
-928
-929
-930
-931
-932
-933
-934
-935
-936
-937
-938
-939
-940
-941
-942
-943
-944
-945
-946
-947
-948
-949
-950
-951
-952
-953
-954
-955
-956
-957
-958
-959
-960
-961
-962
-963
-964
-965
-966
-967
-968
-969
-970
-971
-972
-973
-974
-975
-976
-977
-978
-979
-980
-981
-982
-983
-984
-985
-986
-987
-988
-989
-990
-991
-992
-993
-994
-995
-996
-997
-998
-999
-1000
-1001
-1002
-1003
-1004
-1005
-1006
-1007
-1008
-1009
-1010
-1011
-1012
-1013
-1014
-1015
-1016
-1017
-1018
-1019
-1020
-1021
-1022
-1023
-1024
-1025
-1026
-1027
-1028
-1029
-1030
-1031
-1032
-1033
-1034
-1035
-1036
-1037
-1038
-1039
-1040
-1041
-1042
-1043
-1044
-1045
-1046
-1047
-1048
-1049
-1050
-1051
-1052
-1053
-1054
-1055
-1056
-1057
-1058
-1059
-1060
-1061
-1062
-1063
-1064
-1065
-1066
-1067
-1068
-1069
-1070
-1071
-1072
-1073
-1074
-1075
-1076
-1077
-1078
-1079
-1080
-1081
-1082
-1083
-1084
-1085
-1086
-1087
-1088
-1089
-1090
-1091
-1092
-1093
-1094
-1095
-1096
-1097
-1098
-1099
-1100
-1101
-1102
-1103
-1104
-1105
-1106
-1107
-1108
-1109
-1110
-1111
-1112
-1113
-1114
-1115
-1116
-1117
-1118
-1119
-1120
-1121
-1122
-1123
-1124
-1125
-1126
-1127
-1128
-1129
-1130
-1131
-1132
-1133
-1134
-1135
-1136
-1137
-1138
-1139
-1140
-1141
-1142
-1143
-1144
-1145
-1146
-1147
-1148
-1149
-1150
-1151
-1152
-1153
-1154
-1155
-1156
-1157
-1158
-1159
-1160
-1161
-1162
-1163
-1164
-1165
-1166
-1167
-1168
-1169
-1170
-1171
-1172
-1173
-1174
-1175
-1176
-1177
-1178
-1179
-1180
-1181
-1182
-1183
-1184
-1185
-1186
-1187
-1188
-1189
-1190
-1191
-1192
-1193
-1194
-1195
-1196
-1197
-1198
-1199
-1200
-1201
-1202
-1203
-1204
-1205
-1206
-1207
-1208
-1209
-1210
-1211
-1212
-1213
-1214
-1215
-1216
-1217
-1218
-1219
-1220
-1221
-1222
-1223
-1224
-1225
-1226
-1227
-1228
-1229
-1230
-1231
-1232
-1233
-1234
-1235
-1236
-1237
-1238
-1239
-1240
-1241
-1242
-1243
-1244
-1245
-1246
-1247
-1248
-1249
-1250
-1251
-1252
-1253
-1254
-1255
-1256
-1257
-1258
-1259
-1260
-1261
-1262
-1263
-1264
-1265
-1266
-1267
-1268
-1269
-1270
-1271
-1272
-1273
-1274
-1275
-1276
-1277
-1278
-1279
-1280
-1281
-1282
-1283
-1284
-1285
-1286
-1287
-1288
-1289
-1290
-1291
-1292
-1293
-1294
-1295
-1296
-1297
-1298
-1299
-1300
-1301
-1302
-1303
-1304
-1305
-1306
-1307
-1308
-1309
-1310
-1311
-1312
-1313
-1314
-1315
-1316
-1317
-1318
-1319
-1320
-1321
-1322
-1323
-1324
-1325
-1326
-1327
-1328
-1329
-1330
-1331
-1332
-1333
-1334
-1335
-1336
-1337
-1338
-1339
-1340
-1341
-1342
-1343
-1344
-1345
-1346
-1347
-1348
-1349
-1350
-1351
-1352
-1353
-1354
-1355
-1356
-1357
-1358
-1359
-1360
-1361
-1362
-1363
-1364
-1365
-1366
-1367
-1368
-1369
-1370
-1371
-1372
-1373
-1374
-1375
-1376
-1377
-1378
-1379
-1380
-1381
-1382
-1383
-1384
-1385
-1386
-1387
-1388
-1389
-1390
-1391
-1392
-1393
-1394
-1395
-1396
-1397
-1398
-1399
-1400
-1401
-1402
-1403
-1404
-1405
-1406
-1407
-1408
-1409
-1410
-1411
-1412
-1413
-1414
-1415
-1416
-1417
-1418
-1419
-1420
-1421
-1422
-1423
-1424
-1425
-1426
-1427
-1428
-1429
-1430
-1431
-1432
-1433
-1434
-1435
-1436
-1437
-1438
-1439
-1440
-1441
-1442
-1443
-1444
-1445
-1446
-1447
-1448
-1449
-1450
-1451
-1452
-1453
-1454
-1455
-1456
-1457
-1458
-1459
-1460
-1461
-1462
-1463
-1464
-1465
-1466
-1467
-1468
-1469
-1470
-1471
-1472
-1473
-1474
-1475
-1476
-1477
-1478
-1479
-1480
-1481
-1482
-1483
-1484
-1485
-1486
-1487
-1488
-1489
-1490
-1491
-1492
-1493
-1494
-1495
-1496
-1497
-1498
-1499
-1500
-1501
-1502
-1503
-1504
-1505
-1506
-1507
-1508
-1509
-1510
-1511
-1512
-1513
-1514
-1515
-1516
-1517
-1518
-1519
-1520
-1521
-1522
-1523
-1524
-1525
-1526
-1527
-1528
-1529
-1530
-1531
-1532
-1533
-1534
-1535
-1536
-1537
-1538
-1539
-1540
-1541
-1542
-1543
-1544
-1545
-1546
-1547
-1548
-1549
-1550
-1551
-1552
-1553
-1554
-1555
-1556
-1557
-1558
-1559
-1560
-1561
-1562
-1563
-1564
-1565
-1566
-1567
-1568
-1569
-1570
-1571
-1572
-1573
-1574
-1575
-1576
-1577
-1578
-1579
-1580
-1581
-1582
-1583
-1584
-1585
-1586
-1587
-1588
-1589
-1590
-1591
-1592
-1593
-1594
-1595
-1596
-1597
-1598
-1599
-1600
-1601
-1602
-1603
-1604
-1605
-1606
-1607
-1608
-1609
-1610
-1611
-1612
-1613
-1614
-1615
-1616
-1617
-1618
-1619
-1620
-1621
-1622
-1623
-1624
-1625
-1626
-1627
-1628
-1629
-1630
-1631
-1632
-1633
-1634
-1635
-1636
-1637
-1638
-1639
-1640
-1641
-1642
-1643
-1644
-1645
-1646
-1647
-1648
-1649
-1650
-1651
-1652
-1653
-1654
-1655
-1656
-1657
-1658
-1659
-1660
-1661
-1662
-1663
-1664
-1665
-1666
-1667
-1668
-1669
-1670
-1671
-1672
-1673
-1674
-1675
-1676
-1677
-1678
-1679
-1680
-1681
-1682
-1683
-1684
-1685
-1686
-1687
-1688
-1689
-1690
-1691
-1692
-1693
-1694
-1695
-1696
-1697
-1698
-1699
-1700
-1701
-1702
-1703
-1704
-1705
-1706
-1707
-1708
-1709
-1710
-1711
-1712
-1713
-1714
-1715
-1716
-1717
-1718
-1719
-1720
-1721
-1722
-1723
-1724
-1725
-1726
-1727
-1728
-1729
-1730
-1731
-1732
-1733
-1734
-1735
-1736
-1737
-1738
-1739
-1740
-1741
-1742
-1743
-1744
-1745
-1746
-1747
-1748
-1749
-1750
-1751
-1752
-1753
-1754
-1755
-1756
-1757
-1758
-1759
-1760
-1761
-1762
-1763
-1764
-1765
-1766
-1767
-1768
-1769
-1770
-1771
-1772
-1773
-1774
-1775
-1776
-1777
-1778
-1779
-1780
-1781
-1782
-1783
-1784
-1785
-1786
-1787
-1788
-1789
-1790
-1791
-1792
-1793
-1794
-1795
-1796
-1797
-1798
-1799
-1800
-1801
-1802
-1803
-1804
-1805
-1806
-1807
-1808
-1809
-1810
-1811
-1812
-1813
-1814
-1815
-1816
-1817
-1818
-1819
-1820
-1821
-1822
-1823
-1824
-1825
-1826
-1827
-1828
-1829
-1830
-1831
-1832
-1833
-1834
-1835
-1836
-1837
-1838
-1839
-1840
-1841
-1842
-1843
-1844
-1845
-1846
-1847
-1848
-1849
-1850
-1851
-1852
-1853
-1854
-1855
-1856
-1857
-1858
-1859
-1860
-1861
-1862
-1863
-1864
-1865
-1866
-1867
-1868
-1869
-1870
-1871
-1872
-1873
-1874
-1875
-1876
-1877
-1878
-1879
-1880
-1881
-1882
-1883
-1884
-1885
-1886
-1887
-1888
-1889

5 The disassembled axial-flow pump unit is shown in
FIG. 2. The inlet/gear housing 18 comprises a chamber for
housing the gear and bearing assemblies, as well as a water
tunnel having an inlet (not visible in FIG. 2) formed in
the bottom of the housing and an outlet 34 formed in the
rear face of the housing. The inlet/gear housing 18 is
further provided with an opening 36 in its top face and an
opening 38 in its forward face for respectively receiving a
bearing head 40 of a vertical drive shaft assembly and a
bearing head 42 of a horizontal impeller shaft assembly. In
addition, the inlet/gear housing 18 comprises a pair of
exhaust gas outlets 44, formed in the rear face, which
communicate with an exhaust gas inlet 46, formed in the top
face. The top face of the inlet/gear housing 18 further
comprises a plurality of throughholes for receiving a
corresponding plurality of fasteners for attaching the
inlet/gear housing to the exhaust housing (not shown in
FIG. 2).

20 The outlet housing 20 comprises a mounting flange
48 with throughholes for receiving fasteners for attaching
the outlet housing to the rear face of the inlet/gear
housing. The outlet housing converges in the rearward
direction to form an exit nozzle having a discharge outlet
50. A pair of bosses 52 are integrally formed on the
outside of the exit nozzle to provide reinforcement around
the holes which respectively receive the steering pivot
pins 24. Also, a pair of exhaust gas passages 54 (only one
of which is visible in FIG. 2) are integrally formed as
parts of the outlet housing 20. Each exhaust gas passage 54
has an inlet connected to a respective exhaust gas outlet
44 of the inlet/gear housing 18, and an outlet 56 (only one
of which is visible in FIG. 2).

35 As shown in FIG. 2, the steering nozzle 22
comprises a pair of pivot arms 58 which have apertures for
penetration by the pivot pins 24 and a lateral steering arm

(shown in FIG. 1 only). The steering nozzle can be pivoted about the axis of pins 24 (by pulling and pushing on the lateral steering arm) to produce lateral steering thrust. A pair of bosses 60 are formed on the sides of the exterior of the steering nozzle 22. The bosses 60 provide reinforcement for threaded holes which respectively receive a pair of reverse pivot pins 62. The reverse pivot pins 62 are coaxial with a horizontal axis. The reverse gate is pivotable up and down about the reverse pivot pins 62.

The components for the vertical drive shaft assembly and the horizontal impeller shaft assembly are also shown in FIG. 2. The drive and impeller shaft assemblies (assembled using the components depicted in FIG. 2) are shown in FIG. 4. The following description of the drive and impeller shaft assemblies should be read with reference to both FIGS. 2 and 4.

In accordance with the preferred embodiment of the invention, the vertical drive shaft assembly comprises a generally vertical drive shaft 64 having one end coupled to the output shaft of the engine (not shown) and the other end having a pinion gear 66 coupled thereto. For example, a splined end of the drive shaft 64 may be inserted in a splined recess formed in the pinion gear 66. The pinion gear 66 is rotatably supported by bearing 68 which is held in bearing head 40. A thrust bearing 70 is installed between the pinion gear 66 and the bearing head 40. The bearing head 40 is bolted to the top face of the inlet/gear housing 18 and has a small-diameter portion which sits in the opening 36. The interface of the small-diameter portion of the bearing head 40 and the edge of the opening 36 is sealed by an O-ring 72. A pair of lip seals 74 are placed between the drive shaft 64 and the bearing head 40.

Again referring to both FIGS. 2 and 4, the horizontal impeller shaft assembly comprises a generally horizontal impeller shaft 76 having a bevel gear 78 coupled

to one end and an impeller 80 coupled near the other end. The hub and blades of the impeller 80 are integrally formed as one cast piece. The impeller 80 rotates in unison with the impeller shaft 76. The outer surface of the impeller hub forms the radially inner boundary for guiding the flow of water impelled by the impeller. The impeller 80 may be screwed onto a threaded portion of the impeller shaft 76, while a splined end of the impeller shaft 76 is inserted in a splined recess formed in the bevel gear 78. The chamber for the gear and bearing assemblies and the water tunnel of the inlet/gear housing 18 share a common interior wall 41 which is penetrated by the impeller shaft 76. The impeller shaft penetration is sealed by a seal 77.

The bevel gear 78 is rotatably supported by bearing 82 which is held in bearing head 42. A thrust bearing 86 is installed between the bevel gear 78 and the bearing head 42. The bearing head 42 is bolted to the front face of the inlet/gear housing 18 and has a small-diameter portion which sits in the opening 38. The interface of the small-diameter portion of the bearing head 42 and the edge of the opening 38 is sealed by an O-ring 84.

As seen in FIG. 4, typically the outlet housing 48 comprises a plurality of stator vanes 88 extending radially from a stator hub 90 to the outer shell of the housing. The stator hub 90 comprises a bearing housing 92 which houses a sealed bearing 94 for rotatably supporting the end of the impeller shaft 76. The stator vanes 88 are designed to redirect the swirling flow out of the impeller 80 into non-swirling flow. The straightened flow exits the outlet housing 48 via a convergent thrust nozzle, which increases the water pressure.

As seen in FIG. 4, the beveled teeth of bevel gear 66 intermesh with the beveled teeth of bevel gear 78, thereby coupling the impeller shaft 76 to the drive shaft

64. This beveled tooth coupling converts the rotation about the axis of the drive shaft into rotation about the axis of the impeller shaft. These axes are preferably generally vertical and generally horizontal respectively so that the water discharge is directed generally horizontally. However, a person skilled in the art will readily appreciate that if, for design reasons, the axis of the impeller shaft deviates from true horizontal, the steering nozzle can be designed to compensate for that by fabricating the water passage of the steering nozzle such that its centerline deviates from perpendicularity with the pivot axis (and deviates from parallelism with the impeller shaft axis) by the same angle of deviation. In that case the centerline axis of the steering nozzle will be horizontal even though the impeller shaft axis is not, ensuring that the water is discharged in a horizontal direction.

The separate components shown in FIG. 2 are assembled into the pump unit generally designated with the numeral 100 in FIG. 3. The assembled pump unit 100 is in turn attached to the exhaust housing 16 by fasteners (not shown). The exhaust housing 16 has a vertical passage for the vertical drive shaft 64, the top of which penetrates an opening 114 in the top face of the exhaust housing. To attach the assembled pump unit 100 to the exhaust housing 16, vertical drive shaft 64 must be aligned with the opening 114 and then lowered onto the pump unit until the bottom face of the exhaust housing sits on top of the top face of the inlet/gear housing 18. As seen in FIG. 3, the top face of the inlet/gear housing has four threaded bores 102 which align with corresponding bores 104 in opposing recessed side flanges 106 of the exhaust housing 16. A pair of recesses 108 formed near the bottom on opposing sides of the exhaust housing (only one of which is visible in FIG. 3) provide clearance for insertion and torquing of bolts (not shown) for attaching the assembled pump unit 100 to

the exhaust housing 16. Similarly, a pair of recesses 110 formed near the top on opposing sides of the exhaust housing (only one of which is visible in FIG. 3) provide clearance for insertion and torquing of bolts (not shown) for attaching the engine (not shown) to the exhaust housing 16.

Referring to FIG. 4, the exhaust housing 16 also has an exhaust gas passage 112 which runs from an opening 116 in the top face of the exhaust housing to an opening 118 in the bottom face of the exhaust housing. The opening 116 in the top face of the exhaust housing is in fluid communication with an exhaust port (not shown) of the engine. The opening 118 in the bottom face of the exhaust housing is aligned with the opening 46 (see FIG. 3) in the top face of the inlet/gear housing 18. Consequently, the exhaust gas passage 112 is in fluid communication with the exhaust gas passage of the inlet/gear housing 18. The latter is in turn in fluid communication with the exhaust gas passages 54 on opposing sides of the outlet housing 20. Thus exhaust gases from the engine flow through the connected exhaust gas passages and out the outlets 56 on the outlet housing 20. When the boat is in the water, the outlets 56 are below the waterline.

The exhaust housing 16 also has a vertical water passage 136 for providing cooling water to the engine. The bottom of the water passage 136 is in flow communication with an opening 138 in the stator housing 20. Cooling water is forced upward from the water passage in stator housing 20 by the impeller 80 in a well-known manner.

After the assembled pump unit 100 has been attached to the exhaust housing 16, the entire assembly can be mounted to the hull transom of a boat. First, a thrust bracket 120 is bolted on the back of the transom 12. The thrust bracket 120 comprises a flat mounting plate 122 which lies flat against the transom and a pair of side

thrust walls 124 which are generally parallel to each other and perpendicular to the mounting plate 122. The engine housing 16 has a pair of recesses 126 on opposing sides (only one of which is visible in FIG. 3). The side thrust walls 124 fit in the corresponding recesses 126. The distance separating the opposing surfaces of the side thrust walls 124 is only slightly greater than the width of the exhaust housing 16 as measured across the recessed front portion.

After the thrust bracket 120 has been mounted to the transom 12, a pair of mounting brackets 128 (only one of which is shown in FIG. 3) are bolted to the inner face of the upper portion of the hull transom 12, as best seen in FIG. 4. Each mounting bracket 128 comprises a lower portion with holes for bolts and an upper portion with a transverse hole 132 for receiving a respective end of a tilt pivot tube or rod 130. The mounting brackets 128 are positioned so that the upper portions protrude above the top edge of the hull transom 12, with the transverse holes 132 being coaxial. The exhaust housing 16 is positioned so that the holes 134 in support arms 30 are aligned with the transverse holes 132 in the mounting brackets 128. The tilt pivot tube 130 is then passed through aligned holes 132 and 134 and fastened in place by means of threaded nuts (not shown).

After the exhaust housing with attached pump unit has been mounted to the hull, the engine can be lowered into place atop the exhaust housing and then bolted in place. The engine crankshaft is coupled to the drive shaft 64 and the engine exhaust port is aligned with the opening 116 of the exhaust gas passage 112.

In accordance with the arrangement shown in FIG. 4, the entire water jet propulsion unit, when not latched in place, can be swiveled upward about the axis of the tilt pivot tube 130. In the down position, the

water jet propulsion unit is laterally restrained by the side thrust walls 124 of the thrust bracket 120.

While the invention has been described with reference to preferred embodiments, it will be understood by those skilled in the art that various changes may be made and equivalents may be substituted for elements thereof without departing from the scope of the invention. In addition, many modifications may be made to adapt a particular situation to the teachings of the invention without departing from the essential scope thereof. Therefore it is intended that the invention not be limited to the particular embodiment disclosed as the best mode contemplated for carrying out this invention, but that the invention will include all embodiments falling within the scope of the appended claims.

As used in the claims, the term "duct" means a fluid flow passage having an inlet and an outlet, the duct being formed by a single housing or a multiplicity of housings connected in series.

09927749-081401